Multiplace Hyperbaric Chamber Delivery Systems

Dick Clarke, CHT

The Multiplace Hyperbaric Chamber

Configuration & Operational Overview

Primary Training in Hyperbaric Medicine

Columbia, South Carolina

Operational, Research & Clinical Settings

- Military (diving & aviation)
- Commercial, professional & industrial diving worksites
- Recreational diving destination support
- Civil engineering (caisson & tunnel projects)
- Academic hyper-hypobaric programs
- *Clinical hyperbaric medicine*

The Class A Hyperbaric Chamber

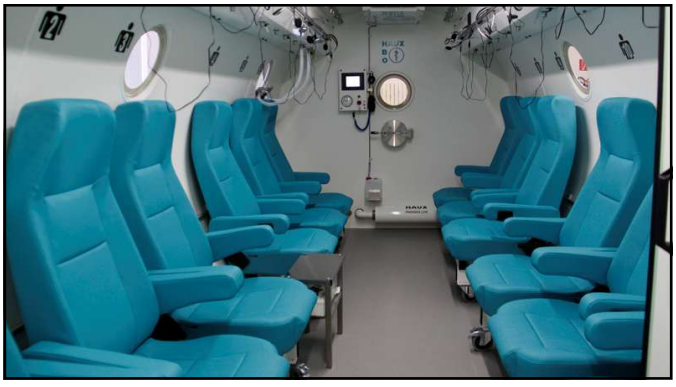
'Human, multiple occupancy' *NFPA-99 classification system*

Multiplace hyperbaric delivery system fundaments

- Chamber configuration
- Air compression & medical gas delivery systems
- Fire suppression capabilities
- Standard operating, clinical, safety & compliance characteristics

Chamber Nomenclature

- Main compartment vs. main lock/inner lock
- Entrance compartment vs. entry/outer lock
- Hatch vs. man way; 'door' on modern clinical units
- Medical lock vs. supply lock
- View port vs. window
- Inside attendant vs. tender/medic

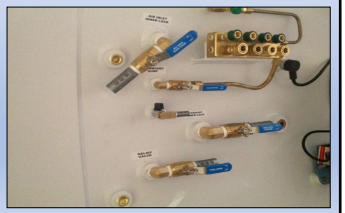


Hatches open into compartment they seal

Outer compartment cannot be pressurized to greater degree than inner compartment

Hatches sealed by pressure differential, not by securing devices

Anti-suction protection, isolation valves; identification



Chamber Air Compression Options

Low pressure compressor > LP volume receiver
125-200 psig

High pressure compressor > HP storage receiver
>2,000 psig

High pressure storage cylinders
>2,000 psig

Low Pressure Compressor Types

Internal combustion engine

Rotary screw

Compressor supplies chamber via air 'receiver'

small reserve for initial compression

receiver air initially cooler than direct compressor air

Air Purity

Compressors: responsibly of end users

Cylinders: responsibility of product manufacturer/supplier

~wide range of standards

Oxygen percent

Carbon dioxide; carbon monoxide

Oil vapor; water vapor

Sulphur dioxide; nitrogen dioxide

Nitric oxide, other potential contaminants

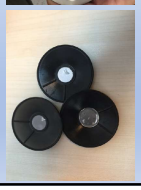
Filtration of Compressed Air Supply

Filter types

Particulate; to remove particles & dust

Activated carbon; removes odors & gases

Coalescing; aerosols to droplets, for drainage



Medical Gases

100% oxygen, clinical HBO therapy

Nitrox (nitrogen oxygen mixtures)

Heliox (helium oxygen mixtures)

Patient Oxygen Delivery Systems

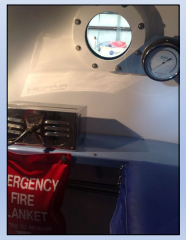
- No ¼ turn valves on HP system; metering types only
- Pressure reduction to source, if HP cylinders
- Control panel O_2 analyzer
- 'Overboard dump' mandatory

Fire Suppression/Extinguishment Options

- Fire blankets
- Handheld extinguisher; water or foaming agents
- Water supplied hand line (hose)
- Water supplied deluge system

Fire Blankets

- Small portable deck decompression chambers
- Not permitted in Class A chambers (NFPA 99)



Handheld Fire Extinguisher

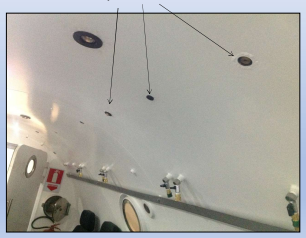
Mandatory Class A chambers (NFPA 99)

- Water & power (air pressure) must be independent of water deluge system
- Water pressure must be 50 psig > chamber working pressure
- One hose in every compartment, two in larger compartments
- Sufficient water volume for not < than 4 min

Water Deluge System

Mandatory Class A chambers (NFPA 99)

Sprinkler inlets



Water storage tank

Air pressure volume tank

Water Deluge System

Water & power (air pressure) supplies must be independent of handline

Water deluge must be delivered three seconds of activation

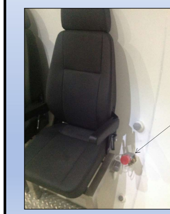
should be sufficient available volume to flow for one minute

should have sufficient stored power (pressure) to operate for 15 seconds

Water Deluge System

Manual activation & deactivation at control panel & inside chamber

Automatic activation not required; surveillance detection is (CCTV)



Activation valves

Evolution of flame detection - automatic activation standard

First edition NFPA-56 DT 1968

"A fixed fire extinguishing system shall be installed in all Class A chambers. It will be capable of manual, as well as automatic, activation".

NFPA 99; Chapter 19 1993

While the requirement for a fixed extinguishing system remains…

"Automatic fire detection systems are optional"

If installed…

"Surveillance fire detectors responsive to the radiation from flame shall be employed"

NFPA 99; Chapter 20, 2002

"Automatic fire detection systems shall not be required"

Inside Attendant

'Fitness to work in pressurized settings'
along lines of HBO pts. but compressed air issue

Pregnancy temporary disqualification
screening standards not well established

Nitrogen narcosis non-issue with routine HBO therapy
complicates DCI cases tx >100 fsw

historic standard of 165 fsw for CAGE & DCS

issues of personal safety, pt care & clinical decision-making

673-016

UHM 2018, VOL. 45, NO. 2 – POLICY: GUIDELINES FOR MULTIPLACE IAS FITNESS TO WORK

Policy

UHMS Medical Fitness to Work Guidelines for Multiplace Inside Attendants

• 1st edition •

Report of the Hyperbaric Oxygen Safety Committee of the Undersea and Hyperbaric Medical Society

This document was written and reviewed by members of the Safety Committee of the UHMS and approved by the UHMS Board of Directors

Preface

The Board of Directors of the Undersea and Hyperbaric Medical Society (UHMS) acknowledges the work of the authors and the UHMS Safety Committee. It is our hope that this publication will prove helpful to practitioners in the field of hyperbaric medicine. The subject matter in this guide refers to the medical fitness of inside attendants (IAs) to work in a compressed-gas environment.

This publication does not replace or supersede any local, state or institutional code or standard. It is a guideline put together by experts in the field, to be used as a reference in evaluating the health and fitness to work of multiplace IAs.

Users of this publication are invited to visit the UHMS web site (www.membership.uhms.org) for more information and are invited to email comments or questions to uhms@uhms.org.

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Alleman T. UHM 2018;45(2):231-247

POLICY • UHM 2018, VOL. 45, NO. 2 231

Same pressure (barotrauma) related risks as patients

Also, at risk for decompression sickness
several cases annually; two nurse fatalities

Procedures to limit DCS incidence
well hydrated; avoid cramped positions

O_2 breathing interval prior to & during ascent

rotating personnel

avoid repetitive exposures

interval before flying >24 hrs.

UHM 2017, VOL. 44, NO. 6 – HEALTH CARE WORKER DCS 673-007

Health care worker decompression sickness: incidence, risk and mitigation

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ABSTRACT

Inadvertent exposure to radiation, chemical agents and biological factors are well recognized hazards associated with the health care delivery system. Less well appreciated yet no less harmful is risk of decompression sickness in those who accompany patients as inside attendants (IAs) during provision of hyperbaric oxygen therapy. Unlike the above hazards where avoidance is practiced, IA exposure to decompression sickness risk is unavoidable. While overall incidence is low, when calculated as number of cases over number of exposures or potential for a case during any given exposure, employee cumulative risk, defined here as number of cases over number of IAs, or risk that an IA may suffer a case, is not.

Commonly, this unique occupational environmental injury responds favorably to therapeutic recompression and a period of recuperation. There are, however, permanent and career-ending consequences, and at least two nurses have succumbed to their decompression insults.

The intent of this paper is to heighten awareness of hyperbaric attendant decompression sickness. It will serve as a review of reported cases and reconcile incidence against largely ignored individual worker risk. Mitigation strategies are summarized and an approach to more precisely identify risk factors that might prompt development of consensus screening standards is proposed.

INTRODUCTION

All individuals exposed to compressed-air environments risk decompression sickness (DCS), a condition resulting from the subsequent lowering of pressure upon return to normal atmospheric conditions. If rate of ascent exceeds that required to maintain tissue inert gas in its soluble form, a state of supersaturation will result. When significant enough, normal physiologic circulatory and ventilatory processes are overwhelmed and bubbles form [1]. Where they accumulate and in what volume will largely dictate their clinical significance.

No definitive diagnostic test exists, although Doppler detection of venous gas emboli (VGE) is considered a useful indicator of decompression stress [2]. VGE are frequently detected across the continuum of the compressed-air workforce and in those who dive [3,4,5]. In a majority of instances they result in no obvious harm, at least acutely. Any longer-term consequences are entirely unresearched.

Minor forms of DCS commonly produce musculoskeletal or cutaneous manifestations. More serious are those involving the brain and spinal cord.

Hyperbaric chambers were first introduced in the 1830s. Their use was entirely speculative and unlikely to have resulted in meaningful benefit. By the turn of the 20th century chambers were employed in support of mass transit tunneling and bridge construction projects [6]. Here, they served to facilitate compressed-air worker decompression and treat any resulting DCS. Over the ensuing decades the world's navies incorporated hyperbaric chambers in support of diving operations.

It was not until the late 1950s that hyperbaric chambers found their way into the hospital setting. Previously, they were located entirely at medically remote worksites. Evolution to mainstream medicine was the result of several additional therapeutic effects identified when oxygen is breathed at elevated pressures, and the term "hyperbaric oxygen therapy" introduced [6].

The "multiplace" (multiple occupancy) hyperbaric chamber is compressed with air. Its patients breathe oxygen via individualized systems and are accompanied by support personnel, working as inside attendants (IAs) [7]. With few exceptions IAs breathe the chamber's compressed-air atmosphere throughout the treat-

KEYWORDS: hyperbaric chamber; inside attendant; decompression sickness

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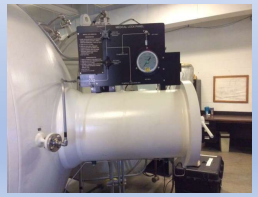
Routine Chamber Operations

Chamber compression on air to pre-determined depth
- *traditionally 45 fsw/2.36 ATA; 33 fsw/2.0 ATA common with hoods*
- *mandatory BIBS for every occupant*
- *O_2 breathing upon arrival tx pressure*

Chamber O_2 constantly monitored; upper limit 23.5%
- *most common source of O_2 leaks is BIBS*
- *air flushing to maintain acceptable range*

Entry lock at 1.0 ATA

Medical lock for small supplies transfer
- *ampules; vials*



Patient/Chamber Safety Perspectives

No direct patient grounding required (as required for monoplace)
- *exception when O_2 atmospheres > 23.5% employed*

Chamber grounding per monoplace, plus internal conductive surfaces enclosing electrical circuits

Ear protection during compression & ventilation

Chamber pressure relief valves
- *one for chamber max working pressure*
- *optional second for max O_2 breathing pressure*

Battery powered equipment
- *sealed/pressure resistant; no in-chamber charging; no battery changing*
- *personal items (cell phone; laptop; tablet; pager; entertainment) prohibited*

"Intrinsically Safe" Hyperbaric Practice

Keeping level of electrical energy too low to cause ignition
- *thereby preventing sparks & keeping temperature low*

Device designs that exclude oxygen
- *plus, purging device with inert gas*

Device strong enough to contain explosion

Moving devices outside hazardous (chamber) area